昆 虫 学 报 *Acta Entomologica Sinica*, October 2004, 47(5): 579 – 585 ISSN 0454-6296

Characterization and comparison of general esterases from two field populations of the grasshopper *Oxya chinensis* (Thunberg) (Orthoptera: Acridoidea)

YANG Mei-Ling, WU Hai-Hua, GUO Ya-Ping, MA En-Bo*

(College of Life Science and Technology, Shanxi University, Taiyuan 030006, China)

Abstract: Malathion susceptibility in the two populations of the grasshopper *Oxya chinensis*, collected from Linyi of Shanxi Province and Xuzhou of Jiangsu Province, China, was determined. General esterases from the two populations were characterized and compared. LD_{50} of the Xuzhou population (13.00 μg/g body weight) was 2.80-fold higher than that of the Linyi population (4.64 μg/g body weight). Inhibition studies of general esterases using four inhibitors, including paraoxon, malaoxon, eserine, and carbaryl, indicated that most general esterases in the two populations were B-type. Kinetic studies showed that the Michaelis-Menten constant (K_m) and the maximal velocity (V_{max}) of general esterases from the Xuzhou population were higher than that from the Linyi population, using α-naphthyl acetate (α-NA), α-naphthyl butyrate (α-NB), β-naphthyl acetate (β-NA) as substrates. The esterase activities in females of the Xuzhou population were 2.02, 1.58, and 1.28-fold higher than those of the Linyi population, using α-NA, α-NB and β-NA as substrates, respectively, and in males they were 2.71, 1.67, and 1.33-fold higher in the Xuzhou population than in the Linyi population. The spectrum of esterase activities showed that *O. chinensis* individuals with high esterase activities were more in the Xuzhou population than those in the Linyi population using the three selected substrates. We speculated that esterases in the Xuzhou population may be biochemically different from those in the Linyi population, and it might be attributed to the different geographic distributions, ecological environment and nutrition resources in the two localities. In addition, the biochemical differences might also be due to the difference in insecticides selective pressure on the two populations of *O. chinensis*.

Key words: *Oxya chinensis*; general esterases; malathion susceptibility; enzyme kinetics; esterase inhibition

1 INTRODUCTION

The grasshopper *Oxya chinensis* (Thunberg) (Orthoptera: Acridoidea) is distributed over a broad range of latitude from Far East coastal region of Russia, Korea, China to Japan and Vietnam. The insect is a prominent agricultural pest in China and represents a most widespread pest, which is commonly and abundantly found in rice paddies, sugar cane, maize, gramineous plants and other crop fields (Zheng, 1993) and brings about great losses for agricultural production.

Due to different ecological environment and geographic distribution, *Oxya chinensis* in different regions have some remarkable variations in growth, development and propagation (Ji, 1999), which may accompany by different genetic structures. Furthermore, a moderate geographical barrier might significantly restrict the gene exchange among populations, which may result in the accumulation of local genetic diversity within a population and the development of genetic differentiation among various populations (Li *et al*., 2004).

Synthetic insecticides, especially organophosphate (OP) insecticides, are often used in management programs to control *O. chinensis* in China owning to their properties of ready degradation and low residues (Shen *et al*., 1988; Sun and Peng, 1991). Recently, it has been noticed by pesticide applicators that control of *O. chinensis* populations in some localities in China has become increasingly difficult with the organophosphates. Numerous studies have demonstrated that esterases play important roles in conferring or contributing to insecticides resistance in insect and other arthropod species (Qiao *et al*., 2003; Li *et al*., 2003). Esterases cause insecticide resistance primarily via sequestration of insecticides by large amounts of esterases present in resistant insects (Devonshire and Moores, 1982; Hemingway and Karunatne, 1998).

Understanding population's genetic background can shed light on effective control of *O. chinensis*. The

基金项目：国家自然科学基金项目(30170612)；山西省科技攻关项目(041005)

作者简介：杨美玲，女，1977 年 9 月生，在读研究生，主要从事抗药性生理生化研究，E-mail: ymlpass@163.com

* 通讯作者 Author for correspondence, E-mail: maenbo2003@sxu.edu.cn

收稿日期 Received: 2004-05-13; 接受日期 Accepted: 2004-07-12

objectives of this study were to (1) compare malathion susceptibility in two field populations of *O. chinensis*; (2) classify general esterases of *O. chinensis*; (3) compare biochemical properties of general esterases in the two populations.

2 MATERIALS AND METHODS

2.1 Insects

The fifth-instar nymphs of *O. chinensis* were collected from Xuzhou of Jiangsu, an coastal province in East China, and Linyi of Shanxi, an inland province in North China, in 2003. The habitat of the Xuzhou population(XZ) consists of a reservoir-shore field, whereas the habitat of the Linyi population (LY) consists of flood river desert sand. All collected specimens were stored at −20℃ for short time stock.

2.2 Chemicals

Bicinchoninic acid solution (BCA), eserine (hemisulfate salt), fast blue B salt (O-dianisidine, tetrazotized), α-naphthol, β-naphthol, α-naphthyl acetate (α-NA), β-naphthyl acetate (β-NA), α-naphthyl butyrate (α-NB) were purchased from Sigma Chemical Co. (St. Louis, MO). Malathion (99.5% pure), paraoxon (90% pure), malaoxon and carbaryl (99% pure) were purchased from Chem Service (West Chester, PA). Bovine serum albumin (BSA) was purchased from Bio-Rad Laboratories (Hercules, CA). Triton X-100 was purchased from Sangon.

2.3 Insecticide bioassay

The susceptibility of *O. chinensis* to malathion was evaluated using a microsyringe injection method. Six different concentrations of malathion were prepared in acetone as a solvent. A sample of 16 – 24 fifth-instar nymphs of *O. chinensis*, which was designated as a replicate, was individually injected with 4 μL of malathion solution or acetone (control) in the abdomen between the second and third sterna. Each bioassay was carried out with six malathion doses and a solvent control; each dose or control was repeated three times. Mortality was determined after the treated nymphs were maintained at room temperature for 24 h.

2.4 Assay of general esterase activity

Thorax of a fifth-instar nymph of *O. chinensis* was homogenized in 0.9 mL ice-cold 0.1 mol/L phosphate buffer (pH 7.5) containing 0.3% (V/V) of Triton X-100. The homogenates were centrifuged at 15 000 × g for 20 min at 4℃, and the supernatants were transferred to fresh tubes and used as enzyme sources. General esterase activities were assayed by the method of van Asperen (1962) with some modifications by Zhu and He (2000), using α-NA, α-NB and β-NA as substrates. Briefly, 15 μL of appropriately diluted enzyme preparation was incubated in a final reaction volume of 150 μL in 0.1 mol/L phosphate buffer (pH 7.5) containing 0.27 mmol/L substrate at 37℃ for 30 min. Reactions were stopped by adding 50 μL of fast blue B-SDS solution. After 15 min, absorbance was determined using a V_{max} kinetic microplate reader and SOFTmax computer software (Molecular Devices, Menlo Park, CA).

2.5 Kinetic analysis of general esterases

Kinetic parameters of general esterases were determined using three selected substrates, *i. e.* α-NA, α-NB and β-NA, as previously described (Zhu and He, 2000). 15 μL of appropriately diluted enzyme preparation, as previously descried in the assay of general esterase activity, was used in each assay. Final concentrations for all three substrates were 6.25, 12.5, 25, 50, 100, 200 and 400 mmol/L. The Michaelis constant (K_m) and the maximal velocity (V_{max}) were estimated by Hanes transformations (Bell and Bell, 1988).

2.6 *In vitro* inhibition of general esterases

Inhibition of general esterases by paraoxon, malaoxon, carbaryl and eserine was studied in the female and male from the two populations. The inhibition reaction was started by incubating 10 μL of the enzyme preparation with 10 μL of each inhibitor at approximately 24℃ for 5 min. The remaining esterase activity was determined immediately using α-NA as a substrate as previously described (Zhu and He, 2000).

2.7 Protein assay

Protein contents of enzyme preparations were determined according to Smith *et al.* (1985), using BSA as a standard. Measurements were performed with the microplate reader at 560 nm (Zhu and Clark, 1994).

3 RESULTS

3.1 Comparison of malathion susceptibility

Comparison of malathion susceptibility of *O. chinensis* in two populations was presented in Table 1. Although the ratio calculated with dividing the LD_{50} of the Xuzhou population by that of the Linyi population was only 2.8, there was significantly difference in LD_{50} between the the Xuzhou and Linyi population. The 95% confidence limits (CL) of LD_{50} were not overlapping between the two populations. The Xuzhou population was 2.8-fold less susceptible to malathion than the Linyi population.

3.2 Assay of general esterases

There were significant differences in esterase specific activities between the Xuzhou and Linyi population (Table 2). General esterase specific activities in females of the Xuzhou population were 2.02, 1.58 and 1.28-fold, and in males were 2.71, 1.67 and 1.33-fold higher than those in the females and males of the Linyi population, when α-NA, α-NB or β-NA was used as a substrate, respectively.

Table 1 Comparison of malathion susceptibility of the fifth-instar nymphs of *Oxya chinensis* collected from Linyi and Xuzhou populations

Population	N^*	Slope ± *SE*	χ^2	P^{**}	LD_{50} (μg/g body weight) (95% CL)	LD_{50} ratio
Xuzhou	390	1.57 ± 0.07	4.14	0.99	13.00 (10.11 – 16.41)	2.8
Linyi	487	2.43 ± 0.06	8.09	0.95	4.64 (4.05 – 5.41)	–

* Number of the *O. chinensis* nymphs tested in each bioassay. ** $P \geqslant 0.05$ indicates a significant fit between the observed and expected regression lines in a probit analysis.

Table 2 Comparisons of general esterase activities [μmol/(min·mg)] using α-NA, α-NB and β-NA as substrates in Linyi and Xuzhou populations of *Oxya chinensis*

Sex	α-NA		α-NB		β-NA	
	LY	XZ	LY	XZ	LY	XZ
♀	0.151 ± 0.036 a	0.304 ± 0.074 a*	0.174 ± 0.055 a	0.277 ± 0.060 a*	0.204 ± 0.044 a	0.262 ± 0.063 a*
♂	0.119 ± 0.031 b	0.321 ± 0.065 a*	0.170 ± 0.055 a	0.284 ± 0.062 a*	0.191 ± 0.041 a	0.254 ± 0.051 a*

Results are presented as the mean ± *SD* ($n = 32$). Means within columns followed by the same letter are not significantly different ($P > 0.05$) using Student's *t*-test. * Means within rows are significantly different ($P < 0.05$) using Student's *t*-test.

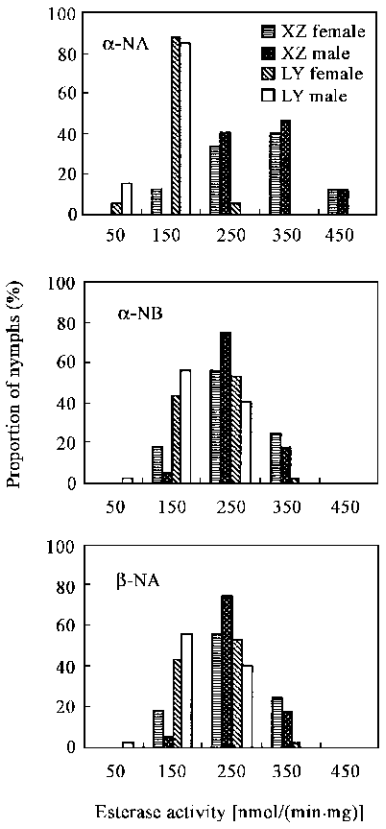

Fig. 1 Frequency distributions of *Oxya chinensis* with esterase activity using α-NA, α-NB, and β-NA as a substrate respectively in Xuzhou (XZ) and Linyi (LY) populations
The esterase activity was individually determined in 32 nymphs of *O. chinensis* for each sex of each population using the esterase microassay.

3.3 Esterase activity spectrum

Fig. 1 showed the different esterase activities spectrum between the two populations using α-NA, α-NB and β-NA as substrates. There were more individuals containing high esterase specific activity in the Xuzhou population than those in the Linyi population for both females and males using the three selected substrates.

3.4 General esterase kinetics

Fig. 2 showed the effects of the concentrations of the three substrates, α-NA, α-NB and β-NA on the activities and Hanes plots (inserted) for kinetics of esterases of Xuzhou and Linyi populations. Enzyme kinetics studies indicated that esterases from the two populations have significant differences in K_m value and V_{max} value (Table 3 and 4). K_m value of general esterases hydrolyzing α-NA, α-NB, β-NA in the females of the Xuzhou population were 1.2, 1.5, 1.3-fold, and in males were 1.1, 1.4, 0.8-fold, respectively, higher than those in the Linyi population. V_{max} values of general esterases in the females of the Xuzhou population were 2.0, 1.6, 1.6-fold, and in male were 1.9, 1.7, 1.2-fold, respectively, higher than those in the females and males of the Linyi population. Among three substrates tested, α-NA appeared to be the most favorable substrate for general esterases of *O. chinensis*, having the lowest K_m values in both populations. In contrast, α-NB is not a preferred substrate for esterases, having the highest K_m values in both populations.

3.5 *In vitro* inhibition of general esterases

Two organophosphates (paraoxon and malaoxon) and two carbamates (eserine and carbaryl) were used for *in vitro* inhibition of general esterases (Fig. 3). Paraoxon was the most potent inhibitor of the esterases. Paraoxon at 10^{-5} mol/L inhibited 91.1% and 93.9% of the esterase activities in females and 93.1% and 92.6% in males within the Xuzhou and Linyi population, respectively. For malaoxon, only 64.6% and 50.5% of general esterase activities in females and 53.5% and 57.8% in males within the Xuzhou and Linyi population, respectively, were inhibited at the same concentration. Carbaryl at the same concentration

inhibited 33.7% and 28.8% of general esterase activities in females and 34.7% and 28.6% in males for the Xuzhou and Linyi populations. Eserine was the least potent inhibitor of the esterases. Eserine at 10^{-5} mol/L inhibited nothing of general esterase activities in the Linyi population and in females for the Xuzhou population and only 3.8% of general esterase were inhibited in males for the Xuzhou population (Fig.3). There were significant differences in the pI_{50} (the negative logarithm of the medium inhibition concentration) values for malaoxon, carbaryl and eserine in females, paraoxon, carbaryl and eserine in males between the two populations (Table 5) by Student's *t*-test.

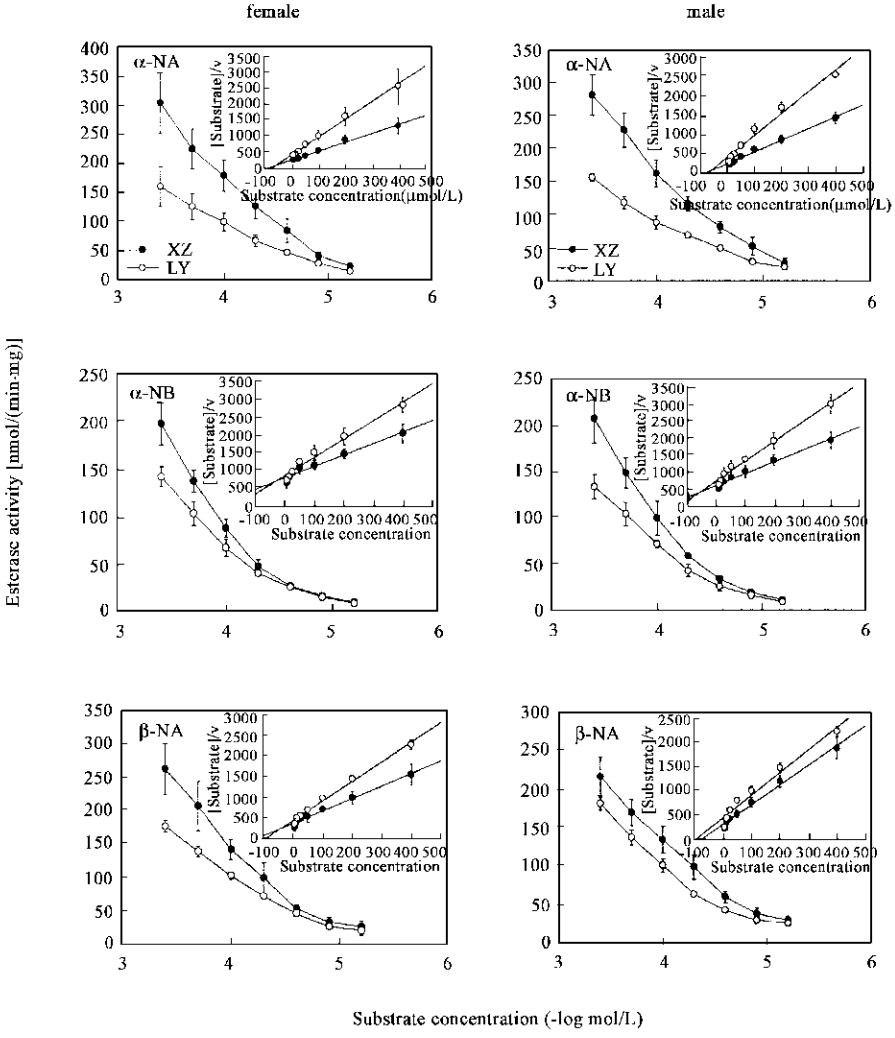

Fig. 2 Effect of substrate concentration on the hydrolysis of α-NA, α-NB, and β-NA by esterases from Xuzhou (XZ) and Linyi (LY) populations

Each point represents the mean of four determinations ($n=4$). Vertical bars indicate *SD* of the mean. The secondary plots (inserted) are Hanes plots of [S] *vs* [S]/*v* for esterase hydrolyzing α-NA, α-NB or β-NA.

Table 3 K_m values (μmol/L) using α-NA, α-NB, β-NA as substrates in the Linyi and Xuzhou populations of *Oxya chinensis*

Sex	α-NA		α-NB		β-NA	
	LY	XZ	LY	XZ	LY	XZ
♀	81.7±17.3 a	101.8±27.1 a	167.1±8.1 a	249.6±33.1 a*	93.1±9.8 a	120.0±15.3 a*
♂	73.5±6.4 a	84.0±5.6 a*	131.8±2.6 b	182.5±14.2 b*	95.4±4.9 a	75.6±7.2 b*

Results are presented as the mean ± *SD*($n=4$). Means within columns followed by the same letter are not significantly different ($P>0.05$) using Student's *t*-test. * Means within rows are significantly different ($P<0.05$) using Student's *t*-test. The same for Table 4 and 5.

Table 4 V_{max} values[μmol/(min·mg)] using α-NA, α-NB, β-NA as substrates in the Linyi and Xuzhou populations of *Oxya chinensis*

Sex	α-NA		α-NB		β-NA	
	LY	XZ	LY	XZ	LY	XZ
♀	0.19 ± 0.05 a	0.37 ± 0.08 a*	0.20 ± 0.02 a	0.32 ± 0.04 a*	0.21 ± 0.01 a	0.33 ± 0.04 a*
♂	0.18 ± 0.01 a	0.33 ± 0.03 a*	0.18 ± 0.02 a	0.30 ± 0.05 a*	0.22 ± 0.01 a	0.25 ± 0.03 b

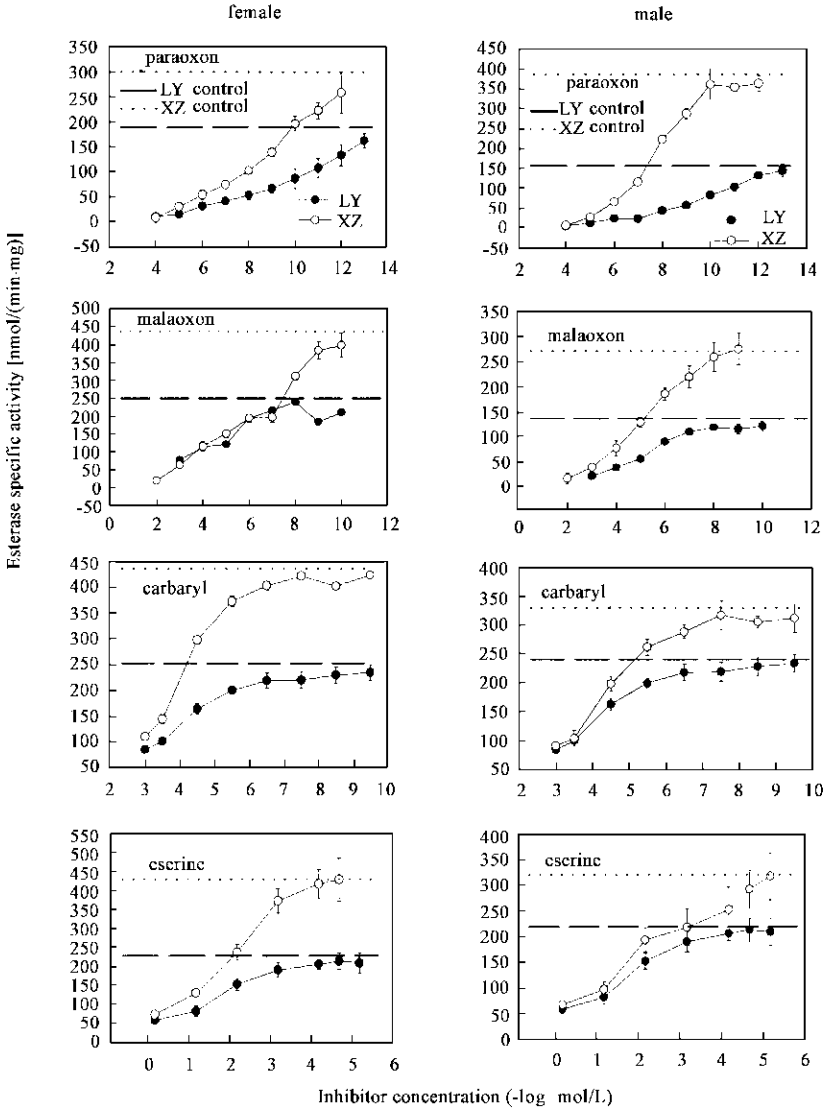

Fig. 3 Inhibition of general esterases from the Linyi (LY) and Xuzhou (XZ) populations of *O. chinensis* by four selective inhibitors, paraoxon, malaoxon, carbaryl and eserine at room temperature (approx. 24℃)
Vertical bars indicated *SD* of the mean of four determinations ($n = 4$).

4 DISCUSSION

General esterases are commonly classified into three types based on their interactions with organophosphates (Aldridge, 1953). A-type esterases are not inhibited by organophosphates but degrade organophosphates as their substrates, whereas B-type esterases are readily inhibited by organophosphates. In contrast, C-type esterases do not interact with organophosphates. Based on this classification, most of general esterases from both the Xuzhou and Linyi populations of *O. chinensis* were B-type because they were very sensitive to inhibition by organophosphate compounds, especially paraoxon. Based on that 1×10^{-5} mol/L paraoxon almost completely inhibited the esterase activities (Fig. 3), but did not

cause inhibition to arylesterases (A-type) (de Malkenson *et al.*, 1984), we estimated that about 91.1% and 93.9% of general esterases in the females and 93.1% and 92.6% in the males for the Xuzhou and Linyi populations, respectively, were B-type esterases. Because B-type esterases can be further classified into carboxylesterases and cholinesterases based on their different responses to inhibition by eserine, our studies also suggested that carboxylesterases were predominant in the composition of general esterases in the two populations of *O. chinensis*. It had been reported that 1×10^{-7} mol/L eserine blocked cholinesterase activity completely in *Myzus persicae* (Sudderuddin, 1973) and *Musca domestica* (van Asperen, 1962), and it also partially inhibited carboxylesterase activity at higher concentrations (Sudderuddin, 1973). Based upon the criteria that cholinesterases can be completely inhibited by 10^{-7} mol/L eserine, it is suggested that almost all of B-type esterases were carboxylesterases for the Xuzhou and Linyi populations (Fig. 3).

Table 5 pI_{50} values for paraoxon, malaoxon, carbaryl and eserine in *in vitro* inhibition to esterases of Linyi (LY) and Xuzhou (XZ) populations of *Oxya chinensis*

Inhibitor	Population	pI_{50}		Regression coefficient, r		r significance, P	
		Female	Male	Female	Male	Female	Male
Paraoxon	LY	10.34 ± 0.98 a	10.12 ± 0.90 a	< −0.97	< −0.99	< 0.0001	< 0.0001
	XZ	9.39 ± 0.38 a	7.75 ± 0.17 b*	< −0.98	< −0.99	< 0.0001	< 0.0001
Malaoxon	LY	4.47 ± 0.05 b	4.94 ± 0.32 a	< −0.98	< −0.97	< 0.001	< 0.0001
	XZ	6.20 ± 0.30 a	5.20 ± 0.36 a*	< −0.97	< −0.98	< 0.0001	< 0.0001
Carbaryl	LY	3.73 ± 0.08 b	3.72 ± 0.07 b	< −0.99	< −0.98	< 0.001	< 0.001
	XZ	3.97 ± 0.09 a	4.02 ± 0.20 a	< −0.98	< −0.98	< 0.001	< 0.001
Eserine	LY	1.49 ± 0.11 b	1.49 ± 0.12 b	< −0.98	< −0.98	< 0.01	< 0.01
	XZ	1.75 ± 0.09 a	2.03 ± 0.18 a	< −0.98	< −0.96	< 0.01	< 0.01

Xuzhou and Linyi populations belong to the different distribution areas of *O. chinensis*. The Xuzhou population is distributed in the reservoir-shore area which consist of a maize field and a weed field, where *O. chinensis* is feeding mainly on maize and gramineous plants and insecticides, mainly organophosphates, were applied in recent years for protecting crop. However, the Linyi population belongs to a river flood area, which is a desolate sand, some weed including primarily gramineous plants are abundant food supply for *O. chinensis*, and insecticides were seldom used for *O. chinensis* control. Furthermore, the higher temperature and humidity in Xuzhou are more favorable to the survival of *O. chinensis* than in Linyi. The distance between the two localities is about 1 200 km. In addition, *O. chinensis* has low migratory capabilities and they often fly in a small scale, which make genetic differentiation among various populations easier to occur. However, in morphology there are no significant differences between the two populations.

Our bioassay results revealed only 2.8-fold decreased susceptibility to malathion in the Xuzhou population as compared with the Linyi population. The marginally decreased malathion susceptibility in the Xuzhou population is likely due to the different ecological breeding habitat, climate and nutrition resources. The significantly different K_m values on esterase activity from the two populations suggested that their catalytic abilities toward the same substrate were different and that the different esterase activities in *O. chinensis* based on comparisons of general esterases activity and spectrum in two populations may be caused by the differentiation of the two populations. Higher V_{max} values in the Xuzhou population also showed its esterase activity was different from the Linyi population. Consequently, we speculated that esterases in the Xuzhou population may be biochemically different from those in the Linyi population, and it might be attributed to the different geographic distributions, ecological environment and nutrition resources in the two localities. In addition, that the biochemical differences might also be due to the different selective pressures of insecticides on Xuzhou and Linyi populations. Therefore, improving ecological environment plays an important role in effective control of *O. chinensis*.

Acknowledgments The authors thank Prof. ZHU Kun-Yan of Department of Entomology, Kansas State University, for his generous help in literature review and theoretical guidance. This work was supported by National Natural Science Foundation of China (Grant No. 30170612), and Science and Technology Commission of Shanxi Province (No.041005).

References

Aldridge WN, 1953. Serum esterases Ⅰ: two types of esterases (A and B) hydrolyzing p-nitrophenyl acetate, propionate and butyrate, and a method for their determination. *Biochem. J.*, 53: 110 − 117.

Bell JE, Bell ET, 1988. Proteins and Enzymes. Prentice-Hall, Englewood Cliffs, NJ. 499 pp.

Devonshire AL, Moores GDA, 1982. carboxylesterase with broad substrate

specificity causes organophosphorus, carbamate and pyrethroid resistance in peach-potato aphids (*Myzus persicae*). *Pestic. Biochem. Physiol.*, 18: 235 – 246.

de Malkenson NC, Wood EJ, Zerba EN, 1984. Isolation and characterization of an esterase of *Triatoma infestans* with a critical role in the degradation of organophosphorus esters. *Insect Biochem.*, 14: 481 – 486.

Hemingway J, Karunatne SHPP, 1998. Mosquito carboxylesterases: A review of the molecular biology and biochemistry of a major insecticide resistance mechanism. *Med. Vet. Entomol.*, 12 (1): 1 – 12.

Ji QW, 1999. *Oxya chinensis* and Synethetic Management. Beijing: Science Press. 1 – 102. [姬庆文, 1999. 中华稻蝗及其综合防治. 北京: 科学出版社. 1 – 102]

Li CX, Ma EB, Zheng XY, 2004. Genetic structure of four geographic populations of *Locusta migratoria manilensis* in China. *Acta Entomol. Sin.*, 47(1): 73 – 79. [李春选, 马恩波, 郑先云, 2004. 中国东亚飞蝗四个地理种群遗传结构的比较研究. 昆虫学报, 47(1): 73 – 79]

Li F, Han ZJ, Tang B, 2003. Insensitivity of acetylcholinesterase and increased activity of esterase in the resistant cotton aphid, *Aphis gossypii* Glover. *Acta Entomol. Sin.*, 46(5): 578 – 583. [李飞, 韩召军, 唐波, 2003. 抗性品系棉蚜乙酰胆碱酯酶和羧酸酯酶的变异. 昆虫学报, 46(5): 578 – 583]

Qiao CL, Hemingway J, Li X, 2003. Quantitative differences between populations of *Culex quinquefasciatus* in both the esterases α and β involved in insecticide resistance. *Acta Entomol. Sin.*, 46(1): 11 – 17. [乔传令, J. Hemingway, 李瑄, 2003. 有机磷抗性致倦库蚊种群中酯酶基因扩增的定量分析. 昆虫学报, 46(1): 11 – 17]

Shen CY, Lu ZC, Shen BF, Huang BL, 1988. The study of rule of occurrence and management of *Oxya chinensis*. *Entomological Knowledge*, 25(3): 134 – 137. [沈彩云, 卢兆成, 沈北芳, 黄伯良, 1988. 中华稻蝗的发生规律及防治研究. 昆虫知识, 25(3): 134 – 137]

Smith PK, Krohn RI, Hermanson GT, Mallia AK, Gartner FH, Provenzano MD, Fujimoto EK, Goeke NM, Olson BJ, Klenk DC, 1985. Measurement of protein using bicinchoninic acid. *Anal. Biochem.*, 150: 76 – 85.

Sun RC, Peng Y, 1991. The study of rule or occurrence and comprehensive management technology of *Oxya chinensis*. *Entomological Knowledge*, 28(6): 330 – 333. [孙汝川, 彭勇, 1991. 中华稻蝗发生规律和综合防治技术的研究. 昆虫知识, 28(6): 330 – 333]

Sudderuddin KI, 1973. An *in vitro* study of esterases, hydrolyzing non-specific substrates, of an OP-resistant strain of the green peach aphid, *Myzus persicae*. *Comp. Biochem. Physiol.*, 44B: 1 067 – 1 076.

van Asperen K, 1962. A study of house fly esterases by means of a sensitive colorimetric method. *J. Insect Physiol.*, 8: 401 – 416.

Zheng ZM, 1993. Taxonomy of Grasshoppers. Xi'an: Shaanxi Normal University Press. 57 – 187. [郑哲民, 1993. 蝗虫分类学. 西安: 陕西师范大学出版社. 57 – 187]

Zhu KY, He FQ, 2000. Elevated esterases exhibiting arylesterase-like characteristics in an organophosphate-resistant clone of the greenbug, *Schizaphis graminum* (Homoptera: Aphididae). *Pestic. Biochem. Physiol.*, 67: 155 – 167.

Zhu KY, Clark JM, 1994. Purification and characterization of acetylcholinesterase from the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). *Insect Biochem. Mol. Biol.*, 24: 453 – 461.

(责任编辑: 黄玲巧)

中华稻蝗两地理种群酯酶特性的比较研究

杨美玲, 吴海花, 郭亚平, 马恩波

(山西大学生命科学与技术学院, 太原　030006)

摘要: 对采自江苏徐州和山西临猗两个种群中华稻蝗进行了马拉硫磷敏感性的生物测定, 同时对两个种群的酯酶特性进行了比较研究。生物测定结果表明, 徐州种群的 LD_{50} 值(13.00 μg/g 虫重)是临猗种群(4.64 μg/g 虫重)的 2.8 倍; 用对氧磷、马拉氧磷、西维因及毒扁豆碱等四种抑制剂对该两个种群的酯酶的体外抑制研究表明, 两个种群所含酯酶大都为 B 型酯酶; 酯酶动力学研究结果表明, 徐州种群动力学参数米氏常数(K_m 值)和最大反应速度(V_{max} 值)均较临猗种群为高; 用 α-乙酸萘酯(α-NA)、α-丁酸萘酯(α-NB)和 β-乙酸萘酯(β-NA)三种底物测定酯酶活性, 在雌性稻蝗中, 徐州种群比临猗种群分别高 2.02、1.58 和 1.28 倍, 雄性中则分别高 2.71、1.67 和 1.33 倍; 对两个种群酯酶活性频率分布进行比较, 徐州种群中酯酶活性高的个体数远大于临猗种群。我们推测徐州种群酯酶的生化特性可能不同于临猗种群, 这可能与地理分布、生态环境和食物条件不同有关, 杀虫剂选择压力不同可能也起一定的作用。

关键词: 中华稻蝗; 酯酶; 马拉硫磷敏感性; 酶动力学; 酯酶抑制

中图分类号: Q965.9　　**文献标识码**: A　　**文章编号**: 0454-6296(2004)05-0579-07